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Degrowth, energy descent, and ‘low-tech’ living: Potential pathways for increased resilience in times of crisis

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ABSTRACT

The use or misuse of advanced technology is a key factor driving global environmental degradation, but advanced technology is also widely assumed to be the solution to many environmental problems. In contrast to that dominant approach, this paper outlines a variety of what the authors call ‘low-tech’ options – such as solar shower bags, washing lines, alternative heating and cooling methods, and cycling – and raises questions about the extent to which these types of ‘simple living’ practices could help increase household resilience in conditions of economic disruption, instability, or crisis. The analysis is framed by an ‘energy descent’ scenario, in which an individual, household or community either chooses a reduced-energy way of life, motivated by climate change mitigation, or has such a way of life imposed upon them due to declining fossil fuel availability or economic disruption. The authors see such a future as plausible – and in some contexts has already arrived or has always been the case – hence the relevance of this analysis, which has both quantitative and qualitative dimensions. Furthermore, while the focus herein is on low-tech living at the household level, it is argued that prefiguring a ‘simpler way’ to live has deeper significance too, in that it could help create the cultural conditions needed for a politics and macroeconomics of degrowth to emerge, which the authors maintain is a necessary part of any decarbonisation project. Challenges facing low-tech options are also acknowledged, including the ever-present risk of rebound effects and other indirect impacts.

1. Introduction

Energy is often called the ‘lifeblood’ of civilisation, yet the overconsumption of fossil energy lies at the heart of two of the greatest challenges facing humanity today: climate change and peak oil (Anderson, 2015; Mohr et al., 2015). While transitioning to renewable or low-carbon energy systems is an essential ‘supply side’ strategy in response to climate change and peak oil (Wiseman et al., 2013), the extent of the problems and the speed at which decarbonisation must occur means that there must also be a ‘demand side’ response (Anderson and Bows, 2011). As outlined below, this means consuming much less energy not just ‘greening’ supply, at least in the most developed, energy-intensive regions of the world.

The dominant approach to reducing carbon emissions is through the application of what could be called ‘hi-tech’ options, such as electric vehicles, solar panels, and new, energy-efficient appliances. The primary reason this approach to sustainability is socially and politically popular is because it does not significantly challenge high-consumption lifestyles or the dominant macroeconomics of growth (Hamilton, 2003). Indeed, it typically assumes that people need to purchase *more* things in order to live sustainably, not less. From this techno-optimistic perspective, the primary societal goal is to maintain a growth-orientated consumer economy and attempt to decouple this form of life from environmental impact via technological innovation and market mechanisms (Hatfield-Dodds et al., 2015; Kerschner and Ehlers 2016). The alternative strategy of moving away from energy-intensive, consumerist lifestyles and adapting to an energy descent pathway of planned economic contraction – or degrowth – remains largely unspeakable in mainstream political and economic contexts (Purdey, 2010).

Focusing on that alternative strategy, this paper outlines a variety of what are called ‘low-tech’ options – such as solar shower bags, washing lines, alternative heating and cooling methods, and cycling – and raises questions about the extent to which these types of ‘simple living’ practices could help increase household

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resilience in conditions of economic disruption, instability, or crisis (Greer, 2009; Tverberg, 2012; De Decker, 2016). While a widespread adoption of the low-tech options under consideration may have the potential to reduce and decarbonise energy consumption – and thus lead to significant environmental benefits – that argument would require a full life-cycle analysis, which is not attempted here. Instead, the paper explores the ways in which low-tech options might help households meet essential needs in circumstances where energy-intensive lifestyles are no longer available or affordable due to energy scarcity or economic crisis. It is argued that such a future is plausible – and in some contexts has already arrived or has always been the case – hence the relevance of this analysis to the contemporary global situation.

While acknowledging the range of complex theoretical issues surrounding definitions of technology (see Schraff and Dusek, 2003), this practically-focused paper proceeds on the basis that 'technology' can be understood simply as a tool, method, or design practice that helps humans solve problems and achieve goals. More specifically, for present purposes, a technology can be considered 'low-tech' if it does not require electricity or fossil fuels to operate, or if it relies on passive or direct (non-electric) solar, wind, or human-powered energy. For example, a washing line uses direct wind and solar energy to dry clothes (low-tech), not electricity to power a clothes dryer (hi-tech). Similarly, a bicycle uses human-powered energy to operate (low-tech), whereas a car uses fossil fuels or electricity (hi-tech). There are of course important questions about the embodied energy of technologies that need to be considered in any such analysis, but for all the low-tech options under review it will be seen that they have far lower and sometimes negligible embodied energy compared with their hi-tech alternatives. While this distinction between low-tech and high-tech defies analytically sharp definition, it is sufficiently suggestive of two alternative approaches for present purposes.

A literature review suggests this is the first scholarly analysis of low-tech living in an energy descent scenario (but see De Decker, 2016). While this study contributes to filling this knowledge gap, the research agenda is in its infancy and it is acknowledged that this study has significant limitations. Nevertheless, by providing a theoretical consideration of low-tech living as a path to increased resilience, as well as presenting some quantitative findings, it is hoped that this might open up space to reimagine the human relationship to technology in ways that are relevant to the theory and practice of degrowth. Significant challenges of low-tech options will also be acknowledged, including the ever-present risk of rebound effects and other indirect impacts (Figge et al., 2014).

There are two other preliminary issues deserving of immediate comment. First, it is important to clarify that the following examination of low-tech options should not be interpreted as a blanket rejection of appropriate hi-tech options. The key word there, of course, is 'appropriate' (Schumacher, 1973) – or, to use Illich's (1973) term, 'convivial'. There is surely a place for hi-tech innovations like solar PV and wind turbines, and arguably computers should or could be a part of the good, sustainable, and interconnected society (although let us not forget that life went on well enough without computers not so long ago). Without doubt, many medical treatments are genuine 'goods' also, and the list could go on. The point, therefore, is not so much to reject hi-tech innovation so much as it is to highlight the potential of various low-tech alternatives.[1]

[1] For example, in one of the few contributions in the existing literature on low-tech options, De Decker (2014) shows, counter-intuitively, perhaps, that some simple but well-designed wood stoves can be more energy efficient than modern cooking stoves.

Finally, while the focus herein is on low-tech living at the household level, the sub-text of the argument is that prefiguring a 'simpler way' to live (Trainer, 2010) has deeper significance too, in that it helps create the cultural conditions needed for a politics and macroeconomics of degrowth to emerge (Alexander, 2013), which it is argued is a necessary part of any decarbonisation project. In this paper, however, space does not permit any sustained engagement with those underlying political or macroeconomic issues. But their importance is acknowledged here to ensure that the analysis is not interpreted as merely advocating 'lifestyle' solutions to problems that will also require deep structural and systemic responses (Kallis et al., 2012; Lorek and Fuchs, 2013).

2. Degrowth, crisis, and the energy descent future

If once humanity inhabited a relatively 'empty' planet, science is now impressing upon us that Earth is 'full' (Daly, 1996; Meadows et al., 2004). Our expanding dominance of and impact on the biosphere is pushing human civilisation beyond the safe operating space of planetary boundaries (Rockstrom et al., 2015). There are now more than seven billion people on the planet, most of whom – even the richest – are seeking material advancement on a planet that has declining biocapacity (Schramski et al., 2015). Over the last 40 years alone human activity has destroyed over 50% of Earth's vertebrae wildlife (mammals, birds, reptilians, amphibians, and fish) (WWF, 2014). Humanity is being called on to fundamentally and urgently rethink its relationships to nature, economy, energy, and technology.

2.1. Energy descent from a climate change perspective

Not only is the global economy undermining the ecological foundations of the planet's declining biodiversity, the large amount of carbon being emitted into the atmosphere is destabilising the climate in ways that are threatening the viability of the planet for human civilisation. Current analyses indicate we may be facing a future as much as 4 °C hotter by 2100 (Christoff, 2013; IPCC, 2013). This presents humanity with a foreseeable moral tragedy almost unfathomable in its enormity (Gardiner, 2011). Nevertheless, action on climate change remains sluggish, at best.

In international climate negotiations it has been agreed that humanity must avoid a temperature rise of more than 2 °C above pre-industrial levels, a commitment reaffirmed at the Paris conference in December 2015 and strengthened with aspirations of keeping temperature rises below 1.5 °C. Even for the 2 °C goal to be achieved, however, it has been shown that the wealthy 'Annex 1' nations need to decarbonise their economies by 8–10% p.a. or more over coming decades (see Anderson and Bows, 2011; Anderson, 2013, 2015). The problem is that historically, long term emissions reductions of more than 1% p.a. have been associated with recession (Stern, 2006), and while surely greater reductions could be achieved if a society seriously *planned* for decarbonisation, it nevertheless seems clear that reductions of 8–10% year-on-year are incompatible with continued economic growth (for the details of this argument, see Alexander, 2014a).

The basic reasoning here is that decarbonising by 8–10% p.a. will require a significant reduction in overall energy consumption not just a 'greening' of supply, and given the close connection between energy and the economy (Ayres and Warr, 2009), an economy cannot continue growing in terms of GDP while also reducing energy consumption so significantly. In other words, reducing energy consumption significantly, in the time frame available, implies less production and consumption. This is especially so given that transformations of energy systems have historically taken decades to complete (Smil, 2010), suggesting immediate carbon reductions

must come primarily from the demand side, as the incremental transition to renewable energy production scales up.

For these reasons, effectively responding to climate change arguably entails transcending the energy-intensive growth paradigm that has defined industrial civilisation and embracing 'degrowth' strategies of planned economic contraction (Latouche, 2009; Kallis, 2011). Not only does this imply transitioning to renewable or low-carbon energy systems and producing goods and services more efficiently, which can be understood as 'supply side' responses; it also means that the most developed regions of the world simply consume less energy and resources, which is a 'demand side' response that must supplement 'supply side' strategies. Low-tech options may provide a partial means of responding to climate change from a demand side perspective, in ways to be explained, but the primary argument will be that if climate change mitigation or adaptation comes to disrupt life as we know it (Christoff, 2013), low-tech options could provide a means of meeting essential needs if conventional or hi-tech options, and the energy-intensive lifestyles they depend upon, become unavailable or unaffordable.

2.2. Energy descent from a peak oil perspective

As well as climate change, there is also the looming problem of peak oil (and other peak resources), the dynamics of which already seem to be underway (Mohr et al., 2015). Peak oil refers to the point at which the rate of oil production cannot be increased (whether for geological, economic, or geopolitical reasons, or some mixture of such reasons). Since 2005 conventional oil production has been on an undulating plateau (Murphy, 2014), defying historic growth trajectories and forcing producers to meet increasing oil demand by extracting unconventional oils which have far lower energy return on investment (Murphy, 2014; Kerschner, 2015).

This plateau in conventional oil production led to a sharp increase in the price of oil, from its historic average of around $25 per barrel, to an average of over $100 between 2011 and the middle of 2014. But given how dependent industrial economies are on cheap oil (Ayres and Warr, 2009), the higher prices over this period made it harder for those economies to grow, because expensive oil draws discretionary expenditure out of the broader economy and into the energy sector – or, for oil importing nations, out of the national economy altogether (Hamilton, 2011, 2012). Furthermore, by reducing discretionary spending, it becomes harder for people to pay back debts, or to consume in ways that help grow economies, and when debts do not get paid back, and when growth-based economies do not grow, the stability of economic systems begin to deteriorate in undesirable ways (see, e.g., Tverberg, 2012) due to rising unemployment and economic insecurity.

Nevertheless, while expensive oil was stagnating oil-dependent economies and thus inhibiting demand growth (Alexander, 2014b), it was also incentivising increased production of oil, and these two supply and demand dynamics have resulted in the collapse of oil prices since June 2015 (Alexander, 2015b), to around $40 at the time of writing (April 2016). In other words, just as expensive oil was inhibiting demand growth it was also increasing supply of liquid fuels, and basic economic principles dictate that when supply of a commodity is high and demand is low, the price is likely to drop. That in fact is what has happened.

However, most of the unconventional oils that have maintained the supply of liquid fuels over the last decade have high production costs, meaning that they require expensive oil to be profitably extracted. The main implication of continued low oil prices, therefore, is that these unconventional oils may no longer be produced to the same extent. The lower production of these unconventional oils will tend to reduce oil supply, and thus put upward pressure on the price of oil. In fact, it looks as if the lower price of oil is in the process of bursting the shale boom in the United States, with production dropping since April 2015 (Hamilton, 2015).

Without going further into the intricacies of the global oil situation, the point for present purposes is that the dynamics of peaking conventional oil have been unsettling oil markets and producing price volatility, which is having destabilising economic implications that are difficult to anticipate with much confidence. Nevertheless, what is clear is that oil is a non-renewable resource, meaning that at some point in the foreseeable future humanity is going to face a peak and decline in liquid fuels available to the global economy (Mohr et al., 2015). When this point arrives, we may find that an energy descent future is imposed upon us through geological forces, with economic implications that could be extremely disruptive.

The case of Cuba is a useful example here (Friedrichs, 2013). After the collapse of the Soviet Union, Cuba suddenly found itself with greatly reduced fossil fuel availability, and most communities were left with no option but to grow their own food, in their locality, without much access to fossil fuel-dependent pesticides and fertilisers, as well as less oil availability for machinery. For the Cubans, establishing low-tech local, organic food production in a context of energy scarcity provided one means of increasing resilience via low-tech living. In that light, the present hypothesis is that in times of crisis there may be a broader range of low-tech options that can help increase resilience.

2.3. The limits of renewable energy

There is one point deserving of further emphasis in order to complete the foundations of this analysis of low-tech living in an energy descent context. In response to the problems of climate change and peak oil, many people hold up renewable energy as the salvation of industrial civilisation, arguing that all humanity needs to do is transition to renewable energy and the problems of peak oil and climate change will be resolved (e.g. Delucchi and Jacobson, 2011). It is highly doubtful, however, that renewable energy will ever be able to sustain a growth-orientated, industrial civilisation of seven billion (or more) energy-intensive consumers. Although it may be technically feasible from an engineering perspective, the problems of intermittency, storage, and resource scarcity make 100% renewable energy supply much more expensive and problematic than most analysts think (see Moriarty and Honnery, 2012; Trainer, 2013a, 2013b; Zehner, 2012).

Even if electricity could be affordably supplied by 100% renewables, electricity only constitutes about 18% of final energy consumption globally (IEA, 2012), meaning that there is still around 82% of energy to replace, including oil used for transport, pesticides, and plastics, etc. If the world tries to produce that huge non-electricity segment of energy demand with biofuels, the production of biofuels would compete with land for food production, a conflict that also seems to be already underway, despite the relatively low levels of biofuels production today (Timilsina and Zilberman, 2014). Biofuels also have a very low energy return on investment – estimated to lie between 1 and 3 (Murphy, 2014: 12), suggesting that they will never be able to sustain an industrial civilisation as we know it today (Hall et al., 2009).

What all this means is that responding to today's energy, economic, and ecological crises is not simply a matter of transitioning to renewable or low-carbon energy systems, necessary though that is. It also requires that human beings (in the developed world, at least) simply consume *far less energy*. But again, given the close relationship between energy and economy, it is argued that a radical reduction in energy consumption implies embracing a degrowth macroeconomic framework, which means (among other

things) transcending consumerist cultures of consumption and embracing materially sufficient but non-affluent ways of living (see Alexander, 2015a; Trainer, 2010). While this will involve using the most appropriate forms of advanced technologies to help decarbonise economies, the equally important but neglected part of the equation involves a deep behavioural shift away from high-consumption, energy-intensive ways of living. This includes a consideration of low-tech living, which to date has received insufficient attention in the literature.

But again, this does not assume that mere 'lifestyle' responses to climate change and peak oil are enough to address those problems. Nevertheless, the subtext of this analysis is that the deep decarbonisation that is urgently needed must begin with individuals and communities prefiguring a 'simpler way' to live and beginning to build the structures that support that way of life (Trainer, 2010). The relevance of low-tech living therefore goes beyond its potential energy savings, promising though this may be. Low-tech living can also play a part in creating the cultural conditions needed for the fundamental structural transformation of our economies to take place (Alexander, 2013). As argued below, they also deserve attention as means of providing a pathway to building household resilience — the ability to withstand socio-economic shocks — in ways that will be outlined. On another occasion it would also be useful to consider at length the potential that low-tech options might have, not just to increase resilience, but also wellbeing (see, e.g., Illich, 1973). The following analysis indicates that low-tech options are full of potential but also face many challenges.

3. A review of 'low-tech' living

Having outlined why energy consumption must be reduced in developed regions of the world, the analysis will now explore various low-tech options that have the potential to assist in that critically important societal goal. This analysis is particularly relevant to the energy-intensive lifestyles prevalent in the most highly developed regions of the world, but it is also relevant to the poorer parts of the world. With respect to the latter, the argument is not so much that the poorest need to reduce energy consumption so much as they should consider whether low-tech options, which people in developing nations may currently use out of necessity, are actually a means of escaping the conventional development path that is in the process of locking developing nations into high-carbon, industrial modes of existence (Deb, 2009). This approach is especially promising when the low-tech options do not necessarily imply a lower quality of life.

The following review will consider such low-tech options as cycling, solar shower bags, hand-washing clothes and dishes, washing lines, 'simple' warming and cooling techniques, etc., in an attempt to understand the extent to which these options could meet essential needs for cleaning, warmth, transport, etc. without relying on energy-intensive advanced technologies. As well as referring to alternative technologies, low-tech can also refer simply to behaviour change, as opposed to relying on technological solutions of any variety (e.g. putting on warm clothing rather than turning on a heater).

The following sections will describe and analyse the nature of these low-tech options from an energy perspective and compare them theoretically with the hi-tech options they have the potential to replace. Although this lacks the quantitative rigour of a full life-cycle analysis, it is contended that there is still much to be gained by undertaking this preliminary analysis, which has descriptive, qualitative, and quantitative dimensions. At the very least, it is hoped the following analysis draws more attention to the questions raised about low-tech living, in the hope of deepening the understanding of how members of a degrowth society may need to think differently about technology, especially in an energy descent scenario.

As will be seen, many of the low-tech options to be reviewed are more or less effective depending on weather conditions. For example, a solar shower bag will be more effective (and much more pleasant!) in warmer months or regions, and non-electric cooling methods may not be necessary over a longer period in cooler months or regions. What this means is that an analysis of low-tech living is ultimately dependent on time, place and circumstance, and this means universal statements cannot often be made with much confidence. Readers should bear this in mind when considering the implications of the following analysis on their own contexts (i.e. what might apply in Namibia or Australia may not apply to Alaska or Siberia). As the authors are writing in Melbourne, Australia, we tend to privilege that context to help ground the analysis, although generally the analysis is of far broader relevance. Where relevant, we use a CSIRO (2014) figure of 68,000 MJ per year for a 5-star energy rated building as an estimate for annual energy usage for a two-person household (excluding transport, discussed in the following section). This is likely to be an underestimate given a typical Melbourne household built before 2005 is rated at 1.81 stars (Sustainability Victoria, 2014), but the figure is a sufficient guide for present purposes.

3.1. Low-tech transport: walking and cycling

The analysis begins with transport, because it is the largest direct use of energy at the household level, besides electricity.[2] Across the developed world, and increasingly elsewhere, driving to and from work and leisure activities in a private motor vehicle is the primary mode of transport. In Australia, transport (primarily driving) contributes a further household energy demand equivalent to approximately half the direct in-home energy use (ACF, 2007: 5). Accordingly, this provides an area where there is potential for significant savings from a demand side perspective, and one where the low-tech options of cycling and walking hold promise.

Within the degrowth and post-carbon transition literature it is generally accepted that there would be a significant increase in walking and cycling in a degrowth society as a means of decarbonising ways of life (Moriarty and Honnery, 2008). Moreover, some car trips could be avoided altogether through better planning of trips (e.g. do various tasks in one trip rather than numerous trips, carpooling) and lifestyle changes (e.g. entertain oneself in one's locality rather than driving for entertainment). These low-tech options can be contrasted with the dominant hi-tech approach of continuing to travel extensively by car but hoping to decarbonise private transport by way of electric vehicles.[3]

[2] By 'direct' energy consumption we mean the use of electricity, gas, or petrol at the household level, to be distinguished from 'indirect' energy consumption that is embodied in a household's food, goods, services, home, or broader societal infrastructure and services. When we refer to 'in-house' energy demand, we mean direct household energy consumption excluding energy for transport.

[3] The question of to what extent electric vehicles could actually decarbonise transport is a complex one which we will not attempt to explore in detail. Suffice to say that replacing the one billion combustion engine vehicles on the roads today would be a hugely expensive and energy-intensive industrial project, one that would take many years to provide a net energy saving. Of course, bicycles also have embodied energy, and walking is dependent on energy from food. Nevertheless, for present purposes we can safely assume that those low-tech approaches to transport have a far lower embodied energy than automobiles. Indeed, the authors of one study estimate the embodied energy of a bicycle is 1% of that of a new passenger vehicle (Lovelace et al., 2011). It is also worth noting that, from an embodied energy perspective, some studies suggest that maintaining some older cars (or technologies in general) may be less energy-intensive strategy than replacing them with more 'efficient' but new models (see, e.g., Zehner, 2012). Obviously, this point will need to be assessed in technology and context dependent ways.

It is worth acknowledging at once that calls to drive less must avoid being simplistic. Many people are often 'locked in' to driving due to various structural factors such as an absence of safe bike lanes, poor public transport, or living far away from one's place of work or social circles (Sanne, 2002). Those structural factors that influence behaviour are real and should not be understated.

Nevertheless, evidence in Australia, for example, indicates that three quarters of all personal journeys are less than 10 km (Deakin University, 2015), with half of all journeys being under 5 km and one third less than 3 km. It is reasonable to assume that a significant portion of these shorter trips could be replaced with cycling or walking, without hardship. Based on recent evidence on Melbourne travel habits (VISTA, 2013a; VISTA, 2013b), it can be estimated that replacing car and public transport trips under 5 km with cycling or walking would reduce residential energy demand for fossil-fuelled transport by 10.8%. Obviously, some short trips may not be easily replaced with cycling or walking (e.g. moving a tonne of bricks a few blocks down the road), but at the same time, some trips longer than 5 km could be easily cycled. Indeed, a study in the US (Higgins and Higgins, 2005), based on recommended daily exercise, has shown that by substituting walking and cycling for short car trips could reduce US domestic oil consumption by up to 34.9% while also having huge health benefits. This suggests the potential of low-tech travel is considerable.

Realising this potential would require, first and foremost, a cultural shift in attitudes to transport – a shift that could be provoked either by enlightenment around the issues or as a response to economic duress arising from a potential oil crisis or broader economic crisis that makes those shorter trips unaffordable due to reduced discretionary income. It should also be acknowledged, however, that often 'knowledge' about environmental issues has proven to be an insufficient driver of behaviour change, on its own. This points to the complex social-psychological factors that influence behaviour change (see, e.g., De Young, 2014; Jackson, 2005).

Fortunately, there would seem to be a 'double dividend' to low-tech travel. Not only do cycling and walking provide a potential means of reducing energy consumption at the household level, there are also well-documented health benefits that flow from a more active lifestyle (e.g. De Geus et al., 2007; Higgins and Higgins, 2005), especially in cultures suffering an obesity epidemic and defined by highly sedentary ways of living. Low-tech transport could thus benefit both people and planet.

Even if there were a cultural shift that embraced cycling and walking, there would also need to be structural adjustment of societies to maximise the potential for these low-tech options. Relocalisation of economy tends to be a feature of most conceptions of a degrowth economy (Latouche, 2009), and this structural shift away from globalisation would also assist with a transition away from oil dependency (Hopkins, 2008). Degrowth scholars often talk of the importance of making the household a place of production again, not just consumption, and of creating local economies and property systems that would allow people to live close to where they work and socialise (see generally, D'Alisa et al., 2015). In such a context, people would largely be freed from private car dependency as their places of work and social life could be reached by bicycle or walking. It can be seen here that the cultural uptake of technologies can be either supported or inhibited by structural factors, with culture shaping, as it is shaped by, structure, in a dialectical fashion (Alexander, 2013; Nicolini, 2012).

3.2. Low-tech hot water: solar shower bags

Another significant energy demand from a household perspective is heating water for showering. The conventional (hi-tech) method for heating water is to use gas or electricity, but this may be unnecessary on warm days when water for showering can be heated directly from the sun. Solar shower bags provide a low-tech means of heating water in this way. This eliminates the need for using gas or electricity to heat water for showering on days that are sufficiently warm to heat water to a comfortable temperature using only the sun.

Obviously, this method will not be effective in cold regions or during the coldest months of the year (unless one is truly a Stoic!). But it has the potential to significantly reduce electricity or gas requirements in warmer regions and during warmer months. Although personal comfort levels will vary amongst people, the authors can say from experience that on days that are 22 °C or warmer, a solar shower bag provides a pleasant low-tech alternative to using gas or electricity to heat water. In Melbourne, Australia, data shows that between the months of October and April (the warmest period in Australia), there were 108 days above 22 °C during the 2013-14 period (Bureau of Meteorology, 2015). This suggests that the use of solar shower bags could reduce the gas or electricity needed to heat water for showering by almost one third. Warmer regions of the world would have even more potential, while cooler regions would have less. (A similar analysis could be undertaken examining the potential of solar ovens and parabolic dishes – not with the aim of replacing conventional ovens necessarily, but to minimise how often they are used (see Yettou et al., 2014)).

As well as heating water directly from the sun, simple behavioural shifts with respect to showering could significantly reduce energy (and water) demands, irrespective of weather patterns. In Melbourne, average shower duration is 6.6 min (Redhead, 2013: 24). This duration could easily be halved, or more, without interfering with the primary aim of keeping clean, and halving the duration of a shower obviously halves the amount of water that must be heated. Indeed, it could be suggested that, in many cases, people might shower every second day without comprising personal hygiene or social norms in any significant way.

These three methods – using a solar shower bag, taking shorter showers, and showering less frequently (but sufficiently) – provide low-tech or behavioural pathways capable of reducing household energy demand for showering without compromising quality of life. We estimate that implementing these methods in tandem could reduce water heating energy needs by one-third. Given that heating water uses on average 23% of a household's in-house energy budget (ABS, 2010), households could therefore reduce their direct total annual household energy demand by up to 8%. These practices may be indicative of socio-cultural shifts that a degrowth society might need to see in relation to technology (Trainer, 2010, 2012), although they are rarely discussed.

Given that a solar shower bag is essentially just a robust black plastic bag with a shower nozzle, its embodied energy can be safely assumed to be small or even negligible in comparison to the energy it could save over years of operation. In times of economic hardship, such practices could be adopted due to economic necessity rather than for environmental reasons, even if they would have environmental benefits by reducing fossil energy consumption.

3.3. Low-tech thermal comfort: dressing appropriately in a well-insulated house

The largest factor in household energy usage is the consumption of electricity or gas for space heating and cooling, which accounts for 38% of a household's in-house energy use in Australia (South Australian Government, 2016). Again, this demand will be greatly dependent on place, time of year, and personal comfort levels or requirements. Nevertheless, there are various low-tech approaches to staying warm or cool that have the potential to reduce energy demand.

First of all, reductions in the need for heating a house can be achieved by dressing in warm woollen clothing and sleeping under woollen blankets when temperatures are cold. As De Decker (2015) argues, we should consider heating ‘people, not places’. This is an alternative to the hi-tech approach of turning on a heater. The potential of this approach is difficult to quantify because it would seem that there is a large attitudinal factor at play. That is, a person's perceived need to heat a house with electricity or gas is partly (but not fully) a function of one's frame of mind. What this means is that a person's conception of ‘sufficient warmth’ can change depending on the attitudes they bring to the experience (see generally, Corral-Verdugo, 2012).

Fortunately, it could be argued that those attitudes are partly or fully within one's control through the practice of ‘mindfulness’ (Burch, 2013). Mindfulness practice implies the deliberate and disciplined examination or re-examination of habits with the aim of shaping habits rather than being shaped by them (Pusaksrikit et al., 2013; De Young, 2014). A low-tech approach to heating first demands that one reflects on the notion of ‘sufficient warmth’ in order to determine how much warmth is ‘enough’ to live well and in accordance with one's values. This point highlights the inextricable connection between values and technology; that is, what is deemed ‘appropriate’ technology will always be a function of the values and goals that shape human life (Schumacher, 1973).

Part of the challenge here is the fact that human beings are both creatures of habit and very adaptable (Marechal, 2010; Di Tella and MacCulloch, 2010). If people get used to heating their homes with electrical or gas heaters to a certain level they may find moving away from those comfort levels or habits difficult. But if they first dress in warm woollen clothing (the low-tech approach) there may be many times when they discover that they are sufficiently comfortable without needing to turn on an electrical or gas heater (the hi-tech approach). Humans can adapt both ways.

As well as wearing warm clothing, there are two other primary means of reducing the extent of energy needed to heat one's house. First, a well-insulated house means that when a house is heated, that heat is retained as far as possible. Obviously, a poorly insulated house will require more heating because it will constantly be losing its warmth (up to 60% of heat can be lost through ceilings and walls in winter (South Australian Government, 2016)), whereas a well-insulated house may only need to have short bursts of heat to maintain sufficient comfort. Secondly, when heating is deemed necessary, a low-tech approach would minimise the amount of space or rooms being heated (e.g. only heat one room rather than the whole house).

Halving the length of time a heater is operated on every occasion, for example, will necessarily halve its energy usage. In addition to reducing heating duration, by using a heater only on ‘colder’ days (say, those with a maximum temperature of 15 °C or below — approximately 40 days in a year in Melbourne (BOM, 2015)) and containing the heated space to a single, well-insulated room only, it is estimated that a household could reduce its space heating energy requirements by up to 85%. In terms of the household, this represents a substantial energy saving of up to 30% of the total in-house energy budget (South Australian Government, 2016).

In sum, there are various low-tech methods of reducing the energy needed to be sufficiently warm: ensure that one is dressed appropriately in warm woollen clothing; ensure that one's house is well-insulated to retain heat when a heater is deemed necessary; seek to minimise the amount of rooms or space being heated; and only heating to a ‘sufficient’ degree.

This type of analysis could be easily repeated for air-conditioners in times when temperatures are considered uncomfortably hot. Again, mindfulness plays a role here, demanding that people first reflect on what type of temperature is in fact ‘too hot’ to live well. Furthermore, closing curtains or wooden shutters on the hottest days can be a very effective low-tech way to avoid letting excessive heat into a house. Just like with heating a house, when air-conditioning is perceived to be necessary, energy demand can be minimised by reducing the amount of space or rooms being cooled, not cooling further than is necessary for sufficient comfort, and even using a fan in place of an air-conditioner. Putting these alternative cooling strategies in place has the potential to reduce in-house energy demand by up to a further 3% (DEWHA, 2008: 42).

These issues related to heating and cooling spaces can be considered from both sustainability and resilience perspectives. From the sustainability perspective, minimising electrical or gas heating or cooling can be defended on the ground of minimising need for fossil energy thus moving toward a low-carbon way of life. From a resilience perspective, the low-tech approach can be seen as a way to stay sufficiently warm (or cool) even in scenarios where a household could not afford to heat (or cool) their house due to economic instability or resource scarcity.

3.4. Low-tech clothes washing: hand-washing and using a clothesline

As well as transport, water heating, and space heating and cooling, household appliances also contribute significantly to energy use in the residential sector. In combination, they make up to a third of in-house energy demand (DEWHA, 2008). Below, two such appliances are considered: washing machines and clothes dryers.

There are obvious social benefits to maintaining a clean wardrobe, along with economic benefits, given that many jobs are dependent to some extent upon ‘presentability’. However, the process of washing clothes can be highly energy- and carbon-intensive as the standard way of achieving clean clothing in developed nations is to use a washing machine, often in conjunction with a clothes dryer. More than half of the households in Victoria, Australia, own a clothes dryer, with nearly a third of these using it at least once per week (ABS, 2012). Due to the materials and electronics involved, the embodied energy of these appliances is substantial (Ciceri et al., 2010).

An obvious low-tech way to reduce the energy used in the clothes washing process is to wash by hand. As many detergents are able to work effectively in cold water, end-use energy consumption can be reduced to practically zero using this method (requiring only time and human labour, considered below). Moreover, rather than using an electric dryer, the use of a simple clothesline represents an important low-tech alternative to drying clothes (the embodied energy in a piece of string or nylon is certainly negligible in comparison to that of an electric dryer). From experience, clothes can be dried in this manner without hardship throughout the year in Melbourne. At most, it requires some planning in winter to ensure that washing is done on sunny or dry windy days. By washing and drying in this manner, a household may save up to 2% on its total in-house energy budget.

While low-tech clothes washing may provide modest benefits from an energy perspective (more significant benefits if avoiding the embodied energy of hi-tech options is included as a saving), the time and personal energy required to hand-wash a load of clothing can be significant. For most people, life in modern society makes heavy demands on our time, suggesting that the convenience of using a washing machine on most occasions may be perceived to outweigh the energy savings associated with its avoidance. However, some of this burden might be overcome by choosing to wash clothes less often (but sufficiently), and instead attending to obvious stains using spot cleaning methods. Note also that the convenience and apparent labour-saving function of washing machines can induce a ‘rebound effect’, such that people find

themselves washing their clothes far more often than would be the case in the absence of such technologies (Ropke, 1999: 413).[4]

3.5. Low-tech entertainment: powering down the electronics

Electronics, such as televisions, game consoles, mobile phones, and computers, have become pervasive in the 21st century. Increasingly people are bound to these devices to satisfy a range of desires and demands related to entertainment, creativity, information exchange, socialising, and productivity. In many ways, humans use energy-intensive technologies to meet a range of fundamental human needs (Max-Neef, 1991). Nevertheless, there is scope for reducing reliance on such technologies by re-defining and re-imagining the way we satisfy these needs and by embracing low-tech alternatives.

Watching television has become a prominent way in which people, especially Westerners, spend their leisure time. According to government figures, Australians watch approximately 3 h of television per day on average, comprising approximately 7% of total in-house energy consumption (DEWHA, 2008). However, such needs could certainly be met through a number of other, less energy-intensive channels — by reading a book, talking with friends, playing sport or other games, forms of art or activism, and so on. Similarly, social media has become a mainstay today, being used to satisfy human needs for leisure and information, as well as those of affection, identity, creativity, etc. An obvious substitute to using social media is to instigate more face-to-face interactions, which could act to satisfy many of the same needs via old-fashioned community engagement.

This should not imply, though, that alternatives to the use of technology are perfect substitutions, or that they will *necessarily* lead to reduced energy use. For example, more face-to-face contact with others in one's social group could certainly lead to higher energy use if a car or plane is used for transport, or if individuals exchange a social media platform for another high energy consuming social activity.

Despite there being alternatives to hi-tech entertainment and leisure, there are significant barriers to reducing reliance on technologies that must be acknowledged. Most of our economic lives depend, at least to some degree, on the use of information and communication technologies, whether that be a requirement to be contactable by mobile phone, the necessity of using an online database, or simply the ability to respond to emails. In many cases people are culturally locked into such practices. Furthermore, today many of our social lives are lived, in part, 'virtually'. To opt out completely from the online world can effectively reduce one's own social sphere, and for some, reduce the opportunities for meaningful interactions with others or employment opportunities.

On the other hand, an *increased* use of electronics may be warranted or even desirable if it leads to a reduction in other energy-intensive activities, such as driving. For example, the energy savings associated with telecommuting are potentially enormous (Fuhr and Pociask, 2011). Research suggests that telecommuting also tends to have beneficial psychological outcomes for the worker (Gajendran and Harrison, 2007). This again points to the fact that it is too simplistic to either be for or against hi-tech or low-tech living. Technology, after all, is merely a tool; a means to an end. The question being raised in this paper is whether there might be times — more times than one might commonly think — when low-tech options are the most appropriate means to achieve the goals of sustainability and resilience.

4. Indirect impacts of demand-reduction strategies

While space does not permit a thorough analysis of the various indirect impacts of demand-reduction strategies, it is worth highlighting some of the complexities at play here in order to outline further lines of research. The first is the now well known 'rebound effect' — including the 'sufficiency rebound effect' (Alcott, 2008). These phenomena always threaten to take back some or all of the resource reductions gained from efficiency or sufficiency strategies through a reinvestment of those savings in additional resource-intensive activity. While acknowledging the importance of rebound effects, this analysis had presented two forms of response.

The first is the issue of 'mindfulness' (Burch, 2013). If individuals or households are not 'mindful' of rebound effects, then there is a far greater risk of demand-side strategies being less effective than one might first think (Pappas et al., 2015). But if demand-side strategies are employed thoughtfully with due acknowledgement of the risk of rebound effects, then mindfulness practice has the potential of avoiding the phenomenon, in whole or in part. This is an important but under-developed line of research that lies on the frontiers of the psychology of sustainability and behaviour change (see De Young, 2014; Marechal, 2010).

The second issue about rebound effects relates to the 'energy descent' scenario that has framed this analysis. For a rebound effect to occur, this obviously implies the *possibility* of a rebound effect. But in an energy descent or crisis situation, low-tech options may help a household deal with an externally imposed reduction in energy supply *without the possibility of a rebound*, because a rebound implies an energy surplus that simply may not exist in a context of energy or economic disruption (Friedrichs, 2013).

There are also other complex 'indirect' impacts of demand-side strategies that will be noted even though, again, space does not permit detailed examination. One is the indirect effect on service suppliers if demand-side strategies were to be more broadly embraced. Electricity, for example, has relatively fixed costs of production. So in a context of significant household electricity reduction (e.g. through low-tech practices of one form or another) it may become harder for those services to be economically maintained if costs remain the same or even increase while consumption reduces. The indirect impact may be that suppliers struggle to deliver baseline electricity at all if the discretionary electricity consumption is largely eliminated. Though this may be environmentally positive, it could create social and institutional instability with consequences that are hard to predict.

Oil supply provides another example. Many oil producers are already struggling to maintain supply given the period of sustained low prices (Alexander, 2014b), but a cultural shift away from using cars may further depress prices jeopardizing the timely supply of even the most socially necessary oil. On the other hand, these may be the types of challenges that need to be overcome during a degrowth or post-carbon transition, because it would seem unacceptable to recommend superfluous consumption of electricity or oil simply to maintain profits. How to manage or overcome 'lock in' situations requires sustained examination (Sanne, 2002).

5. Conclusion

Adapting to energy descent is a neglected scenario primarily due to a pervasive techno-optimism which assumes that technological innovation and market mechanisms will be able to solve the challenges of climate change and peak oil without the need for

[4] Similar rebounds have been shown with respect to travel. Despite more roads and faster forms of travel being available than in previous decades, studies have shown that many people spend as much time travelling as they did in the past, choosing to travel further distances, more often, than travel the same distances, more quickly (the classical statement being. Illich, 1974: 18-9).

questioning hi-tech, energy-intensive, consumer lifestyles. By contrast, this paper has accepted the possibility and indeed the likelihood of an energy descent future, and explored what role various low-tech options might play in helping households adapt to such circumstances. In isolation, some of low-tech options may seem insignificant in the context of the vast, overlapping crises the world faces. But when considered together – a scientific exposition preliminarily attempted herein – those insignificant and often unexciting low-tech practices begin to give rise to an alternative conception of life which it has been suggested may be the most consistent with a degrowth society. Imagine a household that gives up the car for the bicycle; the dryer for the clothesline; the heater for warm clothing; the television for local socialising with friends; and drastically reduces hot water consumption through behavioural change and the use of solar shower bags on warms days. No one is arguing that these things will solve environmental problems on their own, only that they may signify aspects of what strong sustainable consumption could ultimately require.

By adding up the savings reviewed above – which, notably, do not exhaust the low-tech options or behaviour strategies available – the analysis suggests that total in-house energy use could be reduced by 49%. If we include transport in the household energy accounts, the analysis suggests that low-tech options could reduce overall household energy consumption by 36%. We have acknowledged the various qualifications that must be made to these figures, but nevertheless contend that the results, tentative and context-dependent though they are, indicate that low-tech 'demand-side' strategies are promising and deserving of further study.

This type of analysis could be developed and refined in many directions. For example, how many billion dishwashers would not need to be produced if a culture broadly accepted washing dishes by hand as part of ecological living? These are not questions the mainstream environmental movement is asking. Indeed, techno-optimists may dismiss the entire analysis above as a form of 'primitivism'. Our response would be that techno-optimism is failing on its own terms – that is, the celebration of advanced technology tends to exacerbate environmental problems by facilitating continued growth in material and energy throughput. It follows that people need to explore alternative paths to sustainability and resilience, especially ones that need not imply any reduction in quality of life. Granted, low-tech living is a more humble and less glamorous conception of sustainable progress than that presented in glossy eco-design magazines. But it is a form of life that deserves attention as the dominant technological narrative fails to fulfil its promise of environmental salvation.

Although in times of economic stability and prosperity, many low-tech options may be unlikely to receive much positive support, it has been tentatively suggested that in circumstances of economic disruption or externally imposed energy scarcity, low-tech options have the potential to make households more resilient and less energy dependent. In short, a household that finds itself unable to access or afford, or unwilling to choose, an energy intensive lifestyle, may nevertheless meet some of the essential needs of a good life by adopting the low-tech options reviewed above. We have acknowledged, however, that various indirect impacts, including rebound effects, must also be considered in any demand-side strategy, highlighting the complexity of this subject, both in theory and practice.

No doubt low-tech options will require various behavioural and attitudinal shifts. In particular, some of the low-tech options (e.g. washing clothes by hand) may be far more time intensive than hi-tech methods, and thus are unlikely to be embraced widely in advance of socio-economic disruption of some form. But if or when economic or energy shocks arrive, the low-tech options so easily dismissed today may suddenly seem far more attractive, or simply necessary, as they were in the not-so-distant past.

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